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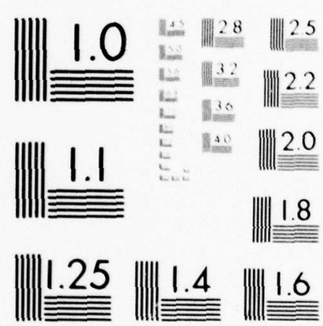

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USNA-EPRD-37

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AN INVESTIGATION OF NEW METHODS FOR THE MAINTENANCE DREDGING OF PIER SLIPS AND AN INVESTIGATION OF SELECTED DREDGING PROBLEMS IN U. S. NAVY-CONNECTED HARBORS

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June 1977

Period 1 July 1976 - 30 June 1977

Unlimited Distribution

Prepared for:
Naval Material Command
Office of Support Technology
Environmental Protection, Code 03421
Washington, D. C. 20360

Energy-Environment Study Group
U. S. Naval Academy
205 Rickover Hall
Annapolis, Maryland 21402

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER: (14) USNA-EPRD-37	2. GOVT ACCESSION NO.
3. RECIPIENT'S CATALOG NUMBER: (9)	
4. TITLE (and Subtitle): (6) AN INVESTIGATION OF NEW METHODS FOR THE MAINTENANCE DREDGING OF PIER SLIPS AND AN INVESTIGATION OF SELECTED DREDGING PROBLEMS IN U. S. NAVY-CONNECTED HARBORS.	5. TYPE OF REPORT & PERIOD COVERED: Final rept. 1 July 1976 - 30 June 1977
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Dr. John F. Hoffman P.E. (10)	8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS: U. S. Naval Academy, Annapolis, Maryland 21402	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS: Naval Facilities Engineering Command (Mr. Stephen Hurley, Code 032B) 200 Stovall St., Alexandria, VA 22332	12. REPORT DATE: (11) June 1977
	13. NUMBER OF PAGES: 24
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): Energy-Environment Study Group, 205 Rickover Hall, U. S. Naval Academy, Annapolis, Maryland 21402 (12) 33p.	15. SECURITY CLASS. (of this report)
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

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DDC	Buff Section	☐
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DISTRIBUTION/AVAILABILITY CODES		
Dist.	AVAIL. and/or SPECIAL	
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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Harbor Pollution, Oceanography, Ocean Engineering, Hydrology

408 548

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The research undertaken in this grant was divided into three parts. One part concerned new dredging methods of low capacity where use is confined to a small area such as a pier slip. The second part concerned evaluating the problem of accretion of sediments in Pier 12 at the U. S. Naval Base at Norfolk, Va., and the problem of the disposal of dredge spoil resulting from channel deepening in the Thames River at New London

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Submarine Base. The third part was to outline a lecture on dredging methods and problems for use at the U. S. Navy Civil Engineering School at Port Hueneme, Calif.

Owing to the expense and awkwardness of utilizing the conventional methods of dredging (hopper dredge, pipeline dredge, bucket and barge) for maintaining pier slips, it is desirable to use a more convenient and more economical method.

Six methods of possible use in coping with the sedimentation problem at U. S. Navy pier slips were evaluated. These are:

1. agitation dredging;
2. Pneuma system of dredging;
3. dredging system utilizing eductors;
4. Dixie dredge;
5. Mudcat dredging system; and
6. Marconoflo slurry system.

The problem at Pier 12 of the Norfolk Naval Base concerned the fouling of condenser tubes while berthing the CV class aircraft carriers. Impairment of steering control and battle-readiness of a carrier due to power failure arising from lack of an electric generating plant cooling are the main issues.

The fouling problem appears to be threefold:

a. biofouling of condenser tubes by masses of marine organisms.

b. fine-grain material previously deposited at the bottom of the slip.

c. erosion of the submarine walls of the relatively narrow berth by the screws of a carrier.

Potential solutions to this problem researched in this report are use of the agitation method of dredging and the Pneuma system of dredging.

The problem at the New London Submarine Base at Groton, Conn., was dredge spoil disposal. Dredging the channel of the Thames River to a depth of 36 feet is necessary to enable the passage of the new nuclear submarines class SSN688. Disposal of the dredge spoil at the New London dump site about 2 or 3 miles offshore caused environmentalists to go to court to request cessation of dumping of the spoil at this site. Under court mandate the U. S. Navy had to cease and desist from dredging and dumping and to institute a monitoring program of the marine environment. One of the important issues was the long-term effect of the spoil on the marine environment. However, nothing was put forth by the opposing environmentalists to indicate what the long-term effects are anticipated or to substantiate the fact that some exist.

Also contained in the report is a section concerning the use of chemical blankets to suppress the resuspension of deposited sediments.

INTRODUCTION

The U.S. Navy's dredging problems can be classified into two broad categories: those that occur because of the presence of facilities such as pier slips, turning basins, etc. and those that occur by the advent of deeper draft ships, aircraft carriers, and submarines necessitiating deeper channels for passage.

The research undertaken in this grant was divided into three parts. One part concerned new dredging methods of low capacity where utilization is confined to a small area such as a pier slip.

Six methods of coping with the sedimentation problem at U.S. Navy pier slips were evaluated. These are:

1. agitation dredging
2. Pneuma system of dredging
3. dredging system utilizing eductors
4. Dixie dredge
5. Mudcat dredging system
6. Marconoflo slurry system

A section concerning the suppression of submarine sediments by chemical blankets was included as a matter of interest in sediment control which may ultimately be of use in the pier slip problem.

The second part concerned the evaluation of two problems. The first problem was the accretion of sediments in the slip at Pier 12 at the U.S. Naval Base at Norfolk, Va. The second problem was the disposal of dredge spoil resulting from channel deepening in the Thames River at New London Submarine Base. These are discussed in the sections that follow.

The third part concerned the preparation of a lecture on dredging methods and problems for use at the U.S. Navy Civil Engineering School at Port Hueneme, Calif., and is contained in Appendix A.

INVESTIGATION OF NEW METHODS FOR THE MAINTENANCE DREDGING OF PIER SLIPS

AGITATION DREDGING

Agitation dredging is the removal of sediment from pier slips and wharves located adjacent to shipping channels by suspending the sediment by agitation at the time of an ebbing tide. The suspended sediment is carried to the main channels by the outflowing water and thence down channel. Agitation is accomplished by dragging an I-beam or similar device behind a tug or by means of the wash from boat propellers.

Owing to the fact that dredging the main channels falls within the purview of the Corps of Engineers, the Corps requires that the Federal Government be reimbursed for all sediment dredged by agitation dredging. For example, in the case of Savannah River piers, Savannah, Ga., reimbursement is at a rate of $176 per hour of dragging time. In this river, the Corps of Engineers' 1973 records indicated that approximately 450 hours of agitation dredging was performed in the Savannah Harbor.[1] The firms utilizing agitation dredging and the breakdown of the 450 hours of agitation dredging is shown in Table 1.

Agitation dredging - Dragged I-beam Method

An extensive study of the effect of agitation dredging on the environment of the Savannah River Harbor was done by a consulting engineering firm, Hussey, Gay, and Bell, Inc.[1] The material on agitation dredging discussed below is based largely on this study.

A comparison of the silting rates of selected East Coast harbors with Savannah Harbor is as follows:

Norfolk, Va.	1" per month
Philadelphia & Delaware River	1/2" per month
Baltimore Harbor	1/2" per month
Wilmington (Sunny Point), N.C.	7" per month
Charleston, S.C.	47" per month
Savannah, Ga.	30" per month

Sediment deposited in vessel mooring areas of the Savannah River is removed by several combinations of drag beams pulled by towboats and propeller washing by small craft. Hydraulic dredges are used on occasions when they are dredging nearby and the costs of mobilization and demobilization is minimal.

The main channels of the Savannah River are maintained by the Savannah District Corps of Engineers and an average of 6,000,000 cubic yards annually is dredged from the Inner Harbor by hydraulic cutterhead dredge.

The tides in the Savannah Harbor are of the semi-diurnal type with a mean tidal range of approximately 6.8 feet at the mouth and 7.4 feet at the City of Savannah. Spring tides have a range of 10 feet. Neap tides have a range of 5 feet. Agitation dredging normally starts approximately one hour after high tide and continues until just before low tide.

Current velocities near the surface at high tide are in the downriver direction and range between 0 and 1 feet per second (fps). About

[1] Hussey, Gay, and Bell, Inc., 1975 "Engineering Report on Agitation Dredging in Savannah Harbor, State of Georgia." 242 p.

Table 1: Total Number of Occasions and Hours, Agitation Dredging, Savannah Harbor, Calendar Year 1973

COMPANY	SAVANNAH HARBOR RIVER MILE	OCCASIONS	% TOTAL	HOURS DREDGING	% TOTAL
Georgia Ports Authority Garden City	18.5-17.8 South Bank	11	5.6	24.75	5.5
Amoco Oil Company	17.0 South Bank	7	3.6	17.75	3.9
Colonial Oil Industries	15.5 South Bank	8	4.1	24.33	5.4
Georgia Ports Authority Ocean Terminal	15.4-15.1 South Bank	106	54.8	250.75	55.9
Charter International Oil Co.	14.4 North Bank	30	15.5	64.75	14.4
East Coast Terminal	12.9 South Bank	2	1.0	6.50	1.4
The Flintkote Company	12.0 South Bank	7	3.6	21.25	4.7
Union Oil Company of California	11.5 South Bank	8	4.1	9.12	2.0
Standard Oil Company	11.4 South Bank	8	4.1	9.12	2.0
Georgia Ports Authority Lash Facility	0.6 North Bank	7	3.6	21.75	4.8
		194	100.0	450.07	100.0

one half to one hour after high tide, the surface currents increase and maximum surface current velocities are on the order of from 4 to 5 fps approximately three hours after high tide.

Mid-depth velocities, at high tide, are in the upriver direction between 1 and 2 fps. About one and one-half hours after high tide, the mid-depth currents reverse to a downriver direction and increase to 1 fps. Maximum mid-depth ebbing velocities are on the order of 2 to 4 fps approximately three hours after high tide.

Data from monitoring surveys showed that the unit cost per cubic yard dredged decreases as the volume of dredging increases. Cost for dredging Georgia Ports Authority slips was $0.013/cubic yard (250 hours); while cost for dredging Colonial Oil Industries slips was $0.25/cubic yard (24 hours). The higher unit cost for Colonial Oil Industries reflects lower efficiency of drag beam agitation dredging at marginal wharves and the use of lesser horsepower towboat with no overtime premium and one hour allowance for hook-up and running time to and from the dredging site. Towing rates for agitation dredging varied from $50 per hour to $87.50 per hour.

The dragged I-beam method of agitation dredging is best suited for dredging small accumulations of sediments such as one to three feet. This process can dredge large areas in a very short time. Dragged I-beam dredging is advantageous in maintaining the project depth within very close limits thus avoiding the need to dredge overdepth for improved efficiency of the dredging process. Overdepth dredging in the Savannah River and the Cooper River has been shown to increase silting rates.

The impact of agitation dredging in the Savannah Harbor on water quality and aquatic life is minimal compared to other maintenance dredging alternatives. Agitation dredging resulted in average turbidity and suspended solids increases of 180 Jackson Turbidity Units and 150 mg/l, respectively, in the water column. Ammonia nitrogen increases were on the order of 0.2 mg/l. Chemical Oxygen Demand increases were on the order of 50 mg/l. Dissolved oxygen depletion was negligible.

The total annual duration of adverse water quality impact at the point of agitation dredging is limited to approximately 680 hours. The impact on the water column dissipated rapidly as the water flowed downriver. This is attributed to the fact that much of the material suspended by agitation dredging resettles to the bottom very rapidly.

Agitation dredging - Propeller Wash

Agitation dredging of pier slips can also be accomplished by utilizing the wash of a propeller. A craft with a sizable propeller wash baffled downward moving forward and backward during the ebbing tide can cause the

deposited sediments to be resuspended and to move to the main channel.

The Corps of Engineers U.S. Army District, Portland, Ore. sponsored a study of the agitation effect of twin-propellered LCM vessel modified with a stern-mounted deflector plate to direct the propeller wash downward thereby scouring the sediments and resuspending them.[2]

Field studies were made at four sites, in Tillamook Bay, Oregon. The boat, the LCM Sandwick, was anchored by a four-point anchoring system over a tidal flat where the depth of water was about 10 feet (3 meters).

The volumes excavated in each of the four holes is shown below:

Location	Duration Seconds	Volume Excavated Cubic meters
West hole	495	182
North hole	150	109
Central hole	300	187
South hole	120	65

If the above figures for duration of agitation dredging are plotted against the volume excavated, the rate of excavation starts off linearly at approximately 2440m^3/hr (3300 yd^3/hr) and then tapers off in about six minutes to a steady-state rate of about 1300 m^3/hr (1700 yd^3/hr). The median grain diameter of the Tillamook sediment was 0.19mm and had a specific gravity of 2.68.

The area of disturbance in the vicinity of the anchored barge at the North hole, which was the largest, was 15 by 24 meters.

Most Navy slips are deeper than the depths in which the LCM Sandwick operated. Therefore, the applicability of the identical approach is unknown. However, the principle of agitation dredging using propeller action can be utilized. A submerged propeller close to the bottom of a pier slip mounted with its axis in a vertical position driven by a motor pneumatically or electrically actuated would direct a flow of water at the bottom sediments. At ebbing tide the resuspended sediments would move out to the main channel and down channel. The propeller and motor mounted in a frame could be suspended from a cable attached to a barge-mounted winch. Thus, the propeller could be positioned at any distance above the bottom desired. Positioning of the barge and movement along the pier slip can be accomplished by means of an outboard motor.

[2] "An Operation Study of the Wheelwash Craft LCM Sandwick" Slotta, L.S. and Higgins, B.J., Oregon State University, Corvalis, Oregon. 1976. 36p.

A more extensive array utilizing two or more motor-driven propellers, may provide wider coverage with fewer passes along the pier slip and thus reduce the operating time.

Finally, as a technique, it may be desirable after removing the sediments from the bottom the slip to the desired depth, to excavate a crater in the slip by means of propeller agitation. This will act as a sink for sediments that migrate into the slip and reduce the frequency of maintenance, especially if the sediments are removed periodically by some form of pumping mechanism such as an eductor.

PNEUMA DREDGE SYSTEM

The pneuma dredge system is a dredging system unlike any other dredge system. It has the capability of being able to remove sediments with a minimum of resuspension in the water column.

The pneuma system consists of four principal components.

- The pumpbody which consists of three cylinders. Each cylinder has only one moving part. That is an inlet check valve, actuated in the filling phase by combined atmospheric and hydrostatic head, and in the discharge phase by the discharge air pressure. The material inlet is at the bottom of the cylinder and the air inlet and discharge and the material discharge are at the top.

- The distributor as a horizontal, dual port variable speed rotary valve driven by either an electric or pneumatic motor. Its function is to receive compressed air delivered through a single line from one or more compressors and distribute it cyclically to the 3 cylinders of the pump body; and to receive the used air from the cylinders and exhaust it to atmosphere. The distributor thus regulates both the volume of air to the cylinders and the frequency with which the air is delivered to each cylinder. Thus the discharge volume and velocity of the system are regulated independently of the cylinder inlet velocity which is a function of submerged depth.

- Air compressors which may be diesel or electrically driven.

- Compressed air delivery lines which are usually a combination of steel pipe and hose. There is a ball and seat check valve in the air line on top of the pump cylinder.

- The mixture delivery line which is a combination of steel and/or plastic pipe, and rubber hose. There is a check valve, of the ball and seat type, in the delivery line at the top of each cylinder.

The cylinders are bolted together in either a linear configuration or a radial configuration. They are connected by pipe and/or hose to the air distributor. The discharge manifold is connected to hose of sufficient length to reach the surface from the planned dredging depths.

The cylinders are submerged, so that the material inlets are in contact with the material to be dredged. Atmospheric pressure exists inside the empty submerged tank. The difference between the internal atmospheric pressure and the external hydrostatic pressure at the submerged depth causes the inlet valve to open and a mixture of water and material to enter the cylinder at a velocity which varies with depth. When the cylinder is filled, external and internal pressures are equalized and the inlet valve closes of its own weight. Compressed air from the distributor enters the cylinder from the top and acting as a piston displaces the mixture in the cylinder. The discharge pipe extends almost to the bottom of the cylinder and below the top of the inlet pipe. The air piston causes the mixture to flow up the discharge pipe and at the same time exerts a closing pressure on the inlet check valve. The distributor operates so as to cause approximately 2/3 of the volume of the cylinder to be discharged, thus preventing the air from entering the delivery line. The air is left with only one avenue of escape - the line thru which it entered. It passes thru that line and escapes to atmosphere thru a port in the distributor rotor that is separated from and diametrically opposed to the entry port. As the pressure is released from the cylinder its internal pressure approaches the atmosphere and the filling cycle resumes.

In order to provide a uniform delivery flow the distributor acts cyclically upon the 3 cylinders with a slight overlap.

Slurry capacities of the Pneuma dredge range from 40 m^3/hour (52 yd^3/hr) to 2000 m^3/hour (2616 yd^3/hr).

The Pneuma System is characterized by:

- compact design
- simplicity of operation
- low working cost
- few wearing parts
- low maintenance
- pumps slurries of high solids content by volume - to 60% in sand and 90% in silts.
- ability to operate to depths of 50 meters with the standard plant.
- maximum portability - all components can be moved by truck.

An additional advantage, not usually true with conventional dredges is environmental acceptability.

EDUCTOR SYSTEMS IN DREDGING

The use of eductors for dredging pier slips is useful in non-cohesive material. The basic eductor works on the principle of the Venturi tube. When a jet of water is constricted in a tapered tube a vacuum is created. Fluid from the surrounding environment moves towards the chamber. If the eductor rests on a sandy submarine bottom, both sand and water are sucked into the vacuum chamber and passed along with the flow. If on a flexible hose, the eductor in this case sinks into the sand to form a crater.

Two eductors were investigated, those manufactured by the Pekor Iron Works, Inc., and those manufactured by the Vita-Motivator Company.

The Pekor eductor was part of a system used to pass littoral drift beneath two jetties to prevent beach starvation at Virginia Beach. This sand moves parallel to the shore in a northerly direction. Before the system was installed, shoal areas at Rudee Inlet resulted from the deposition of sand, prevented the ingress and egress of boats, as well as starved the beach at Virginia Beach. The system was designed and installed by the Waterways Experiment Station (COE) and later sold to the Virginia Beach Erosion Commission at the latter's request.

The basic system consists of an eductor that sucks up sand and pumps it to a dredge pump. The dredge pump passes it through 1800 feet of pipe that underlies Rudee Inlet to the other side where longshore currents transport it northward. A crater formed around the eductor results in the submarine movement of sand laterally to the eductor. According to Mr. Melson, Superintendent of the Beach Erosion Commission, the slope of the crater wall is about one vertical on two horizontal. Thus a crater ten feet deep has a diameter of 40 feet. To facilitate movement, the sand in the vicinity of the eductor is fluidized by two jets located on either side of the eductor. The rate of flow through each jet pipe is 75 gallons per minute (gpm). Once the desired depth is reached, the eductors are manually moved by scuba divers to an adjacent location.

Two eductors are in use at Rudee Inlet to increase production. Each is mounted at the end of a 6-inch flexible hose to enable flexibility in movement. Each eductor is attached to a float three feet in diameter and five feet long. When starting the operation at a location, the float is filled with water and together with the eductor sinks to the bottom. After the prescribed depth is reached by dredging, the water is forced out of the float by compressed air. The eductor and hose, now buoyant, is pushed or dragged manually to a new location where the procedure is repeated. Inasmuch as the flexible hose is heavy, each hose is supported by a pair of floats to enable shifting the hose more easily.

Details of the Virginia Beach by-passing system are listed below:

Operation:	5 to 7 days each week 10 to 24 hours per day
Eductor:	Pekor; cost: $1000
Water Supply Pump for Eductor:	Goulds #3405 6x8, 375 ft head @ 2200 gpm Diesel Driven - 50 horsepower Uses salt water from adjacent inlet
Dredge Pump:	Pekor
Piping:	System 6" diameter regular mild steel pipe. Discharge line of dredge pump - 8 inch diameter 1800 feet long. To date there have been no erosion problems in the piping from transporting sand.
Flexible Hose:	6" diameter; Mfr: Ampex, Long Beach, California
Problems:	The steel packing sleeves on the Pekor dredge pump have been replaced with stainless steel (18-8) packing sleeves for it was found that during shutdown for a day the corrosion products formed caused the packing to loosen and form an unsatisfactory seal between the pump shaft and the housing.

According to Mr. Melson, each eductor moves about 65 cubic yards per hour. Cost of moving sand is roughly estimated at $.50 per cubic yard (1976). (Note: cost per cubic yard at U.S. Naval Station, Norfolk, Va., is $2 per cubic yard (1976) but this cost contains other related costs.)

The problem of using the system for silt was discussed with Mr. Melson. He felt that inasmuch as the silt was cohesive and it would not gravitate toward the eductor. Experiments performed at the Waterways Experiment Station (WES) using silt, according to Mr. W. Fenwick (WES) indicated that the eductor system would work if the eductor were continuously moved.

Contact was made with Mr. J. A. Wynn, of Pekor Iron Works, Columbus, Ga., who indicated that other installations operating on this principal were located at Mexico Beach, Fla., and Santa Cruz, Calif.

The concept of using eductors to remove sediments from pier slips was also discussed with the Vita Motivator Co., New York, N.Y. While their experience included use of eductors for cleaning out barges, dry-docks, etc., where both liquids and solids are involved, they were of the opinion that large scale eductors could be used to keep pier slips clean of non-cohesive material. In the case of cohesive materials, jets could fluidize the sediment. The capacity of VM eductors ranges up to 3900 gpm.

MUD CAT DREDGING SYSTEM

The Mud Cat is a compact, portable machine designed to hydraulically remove sediment deposited in waterways, marinas and impoundments. Silt, sand, muck, weeds, sludge and industrial wastes are cut up and pumped away safely and efficiently. Only a minimum of sediment disturbance takes place and, therefore, does not create a turbidity problem.

In this dredging system, a hydraulically-operated boom lowers the horizontally mounted auger-cutter assembly into the material to be excavated. The auger-cutter assembly dislodges and delivers the material to the pump suction intake. Liquid transports the solids to a centrifugal pump which boosts the pressure of the slurry for pipeline transmission to a remote location.

The unitized design is comprised of an integrally welded pontoon providing flotation for the diesel engine, centrifugal pump, horizontal auger-cutter assembly and the control center. The principal controls are hydraulically operated. Lighting equipment permits 24-hour operation. It is easily transported from site to site and can be launched and retrieved quickly. Generally, a crane is used for this purpose. The overall dimensions are eight feet wide, nine feet and three inches high and 30 to 39 feet long depending on the model.

Prior to placing the machine in operation, an anchored cable network is established and a pipeline is assembled. A portion of the cable is threaded through a winch mechanism which propels the machine in the forward and reverse directions along a guide cable. After the guide cable is properly tensioned and the pipeline connected to the machine, the Mud Cat is ready to be operated.

Materials are excavated as the machine moves in both the forward and reverse directions. Several passes are normally required in the same cut to excavate underwater materials to a predetermined depth or to a maximum depth of 10-1/2 feet (Model MC-10) or 15 feet (Model MC-15). Modification of the equipment has made it possible to dredge to a depth of 20 feet.

When all of the material is excavated in a given cut a "pullover" is made to laterally reposition the cable guide and the procedure is repeated.

Cost of the basic MC-15 dredge is $78,750 (1977); the associated equipment package, less pipeline, is about $6,000.

Mr. Louis E. Shenman, District Sales Manager-Eastern for the Mud Cat Division of National Car Rental System, Inc., was contacted concerning modification of the existing system to dredge to a depth of 38 feet. The following are excerpts from a letter following his discussion of the problem with Mud Cat's engineering department:

"I have discussed the above subject application with Mr. Charles F. O'Brien, Manager of Engineering Services for Mud Cat Division and, based on the criteria which you have given me, mainly, the ability to handle depths down to 38', we have concluded the following:

1. The existing Mud Cat is too small in its present design.
2. The power requirements to operate at 38' depths would have to be increased.
3. Support winches would be required to raise and lower a longer boom due to added weight.
4. A submersible pump, either hydraulically or electrically powered, would have to be designed and mounted on the end of the boom directly behind the auger.

The decision to design for greater depth capability has been a marketing decision. To date, Mud Cat Division has limited its expansion into larger dredges because it has successfully been able to fill the small dredge void that currently exists in the market place. That is not to say that we would not consider a larger Mud Cat with greater depth capability, provided there is a financially sound reason for developing this larger equipment. To do so, would require expanding the hull size of the Mud Cat, thereby increasing the platform on which we could mount a larger power train. Also, the balance of a larger Mud Cat would be greatly affected by a longer boom capable of reaching these greater depths. The Mud Cat, Model MC-15, which is our largest standard design, operates at depths of 15'. In individual cases, the boom has been lengthened to operate at 20' with added buoyancy to support the longer boom. Exceeding of the 20' operating depth, however, appears to be limited by 2 factors--stability and overall seaworthiness, and existing hydraulics inability to raise and lower a longer boom. It would also supply additional power to a submersible pump--either electrically or hydraulically driven.

We have concluded that a larger Mud Cat could be designed if properly funded. The existing Mud Cat, with its auger/mudshield configuration, has been able to achieve relatively low turbidity and high solids ratios while operating in fine, unconsolidated sediments. Also, horizontal and vertical control of the Mud Cat has been maintained by the winch/depth gauge combination. Although a basic redesign of the dredge itself would be required, we believe it will be of great value to the Navy in that the operational features of the existing Mud Cat could be incorporated for purposes of amethodical and environmentally sound dredging project, especially where high solids ratios are desired."

DIXIE DREDGE

The Dixie Dredge Corporation manufactures hydraulic cutterhead dredges of all sizes. Of interest to this study, however, are the smaller economy models suitable for dredging pier slips. Details are listed below.

Model	Power HP	Ladder -ft	Production Cubic Yards Per Hour*
CD-6	125	22	30-85
CD-8	220	22	50-110

*Volume of Solids.

The center section of each hull is 10 feet wide and 30 feet long. The ladder, which is the boom that supports the cutterhead, determines the depth to which the channel can be dredged. A 22-foot ladder indicates a dredged channel depth of 16 feet. Lengths of ladders on other models are as follows: 16 feet (11 feet), 32 feet (26 feet), 50 feet (35 feet), and 70 feet (50 feet). The figure in parenthesis is the depth of dredged channel.

The solids concentration in the slurry varies between 10 percent to 21 percent. Thus these dredges are less efficient than the previously-described dredging methods. Additionally, a more turbid water condition is created than with the previously-described methods and, therefore, is less desirable environmentally. Unless the discharge of slurry is made to an adjacent barge, the inconvenience of a pipeline is encountered.

The cost of the above dredges is in the range of $135,000 to $145,000 (1977). Exact figures require completion of a data sheet for company estimates.

The U.S. Navy owns one of the larger models, Model CS-16 Series 300, a heavy duty 16-inch dredge used for channel and harbor maintenance at the Mare Island Naval Shipyard. The ladder on this model is 50 feet indicating that it can dredge to a 35 foot depth.

MARCONOFLO SLURRY SYSTEM

The Marconoflo slurry system is basically used to suspend fine-grained sediments and to pump them to a desired point. It can transport slurries containing up to 70 percent solids and has had its largest application in the movement of ores and minerals. It has not been used for dredging to date.

A unit normally consists of two jetting nozzles to suspend the material, an eductor to transport the slurry to a centrifugal pump which transfers it through a pipeline to the point of desired discharge. All items are housed in a steel capsule which is suspended from a crane. In the case of pier

slips this crane could be either barge-mounted or could move along the pier depending upon the situation.

Various size units have different output rates. Some examples are listed below:

Size of Unit Slurry Discharge Rate gpm	Product Output Per Hour Dry Tons	Cubic Yards*
500	90-120	60-80
1000	235-290	157-194
2000	470-580	315-389
3000	705-870	472-583

*Assumes dredged material in place to contain one-third water and have a specific gravity of 2.67.

One drawback to the use of this system for dredging is the turbidity that would be created in the suspension process.

The Marconoflo Company was contacted to determine if depths of water on the order of 40 to 50 feet could be successfully dredged with their system. The following are excerpts for the response:

"The only movable system which would work in 40-50 feet of water is the caisson unit described in the information bulletin and the materials reclaim brochure. These units can be supplied with capacities of 500, 1000, 2000 and 3000 gpm of slurry. Each unit would produce about 90 feet of head. They may be supported by a crane, skid or barge.

The price for a 1000 gpm caisson would be about $165,000, a 2000 gpm unit would be about $235,000 and a 3000 gpm unit would cost approximately $325,000. These prices are estimates based on the cost of components at the present time (1977) and will be refined if you are interested in a particular size unit. The price includes the complete Marconoflo system with Marconajet(s), slurry pump, drive mechanism and 100 feet of slurry discharge and high pressure water hoses.

A caisson unit has been used at Iron Ore Company of Canada to recover iron concentrate from 20 feet of water at slurry densities of 50 percent and greater.

The performance of a caisson unit in your application would depend on the characteristics of the material. If you would like specific information pertaining to your particular situation please complete and return the enclosed Material Handling Application Information sheet. The data it contains will allow our engineering department to determine the proper size of unit and to calculate the time required to remove the material."

SUPPRESSION OF SEDIMENTS IN PIER SLIPS WITH CHEMICAL BLANKETS

Although not presently used it may be feasible to use a chemical blanket as a basement to a pier slip in conjunction with propeller wash agitation method. Patent number 3,845,003, granted to Thorndyke Roe, Jr. and assigned the United States of America as represented by the Secretary of Navy, describes the use of the following two distinct film-forming chemical solutions, each of which precipitate where extruded through a slit into sea water:

		Parts by Weight
1.	Polyvinyl butyral resin	1.0
	2-(2-ethoxyethoxy) ethanol	28.4
	Citric acid	13.4
	Dibutyl Phthalate	7.9
	Dimethyldicocoammonium chloride 75% active	0.1
2.	Polyvinyl butyral resin	1.0
	2-(2-ethoxyethoxy) ethanol	24.6
	Chlorinated Paraffins	12.0
	Dibutyl Phthalate	6.0
	Dimethyldicocoammonium chloride, 75% active	2.1

In practice, these solutions have been found to provide a continuous flexible non-toxic plastic film capable of covering the ocean floor sediment and preventing the sediment from becoming disturbed and suspended in the sea water. Also, these non-toxic plastic films were found to have a strength sufficient to support light loads and a strength which increased with deposit time.

Included in the solution is an antistatic agent to reduce the static electricity on the extruded plastic film. This enhances the spreading of the plastic film by allowing the film to spread in thinner sheets than would otherwise be possible. The antistatic agent utilized in the present invention is Dimethyldicocoammonium chloride, 75% active.

The other significant factor in the formulation is the use of a solvent which itself is miscible and preferably soluble in sea water. Consequently, when the solution initially is exposed to the sea water, the solvent commences to dissolve in the sea water permitting the resin system to precipitate out in a desired manner. The initial film formed by the precipitation is sufficiently cohesive to provide a continuous sheet although, as will be apparent, the toughness or strength of the sheet will not be achieved until the solvent has completely dissolved in the water. It is for this reason

that the strength of the sheet will not be achieved until the solvent has completely dissolved in the water.

In the same period, under contract to the Supervisor of Salvage, U. S. Navy, Battelle Memorial Institute developed a two-component overlay method in which sodium alginate containing titanium dioxide as a weighting agent is insolubilized by treatment with dilute hydrochloric acid. The overlay formed instantly and had fair mechanical properties. Its surface was quite slippery; and when walked upon, it tended to extrude or creep out from under one's feet and break up. It had some resilience and very low tensile strength. If a large area is to be covered, adjacent layers of this material cannot be bonded to one another, but must be overlapped or cross-hatched. Because of its requirement for two components, its marginal mechanical properties and its inability to bond to itself, this method is not recommended for future development. Pilot-test costs for these overlays are on the order of $1.00 per square foot (1970).

Experimental runs of fixed-slit dispensers with candidate overlay solutions were conducted in 25 feet of water off Santa Cruz Island and in 50 feet of water of Anacapa Island. These tests indicated that a chemical overlay dispensing system could not be entirely diver operated. Any system which requires divers to swim above the sediment with a dispenser and attached hose was found to be impractical because the dispenser and hose are too cumbersome to be handled in this manner. For this reason, two dispensing system prototypes were proposed: one to be used on a Construction Assistance Vehicle (CAV), and a subsequent model to be used on a deep water submersible.

The CAV provides a load bed that can support a dispensing-system prototype. As the CAV cruises over an intended work site, the dispenser, suspended from the stern, can apply chemical overlay solution on the seafloor. Several parallel runs, overlapped at the edges, would completely cover the site. With the CAV in mind, the main features of the chemical overlay dispensing system include: (1) 600-gallon capacity; (2) at least 100 square feet per minute and 2000 square feet per hour coverage; (3) storage container to be pressure-compensated; and (4) stipulations to ensure convenience and efficiency in operator control.

INVESTIGATION OF SELECTED DREDGING PROBLEMS IN U.S. NAVY-CONNECTED HARBORS

Pier 12 Problem - U.S. Naval Base, Norfolk, Va.

Fouling of condenser tubes while berthing the CV class aircraft carriers has caused a series of memos of concern to be generated by the Commander, Naval Air Force, U.S. Atlantic Fleet, during 1975 and 1976. Impairment of steering control and battle-readiness of a carrier due to power failure arising from lack of electric generating plant cooling are the main issues.

Discussions concerning the subject problem were held with the following personnel:

CDR D. H. Johnston, Ship's Engineering Officer
COMNAVAIRLANT Staff.

LCDR J. S. Mansfield, Berthing Officer,
Naval Station.

LCDR T. P. Connelie, Staff Civil Engineer,
Naval Station.

Mr. George Sims, Special ASsistant for Applied
Biology, NAVFAC Engineering Command.

The problem at Pier 12 occurs on the south side of the pier. Because the flight deck of the CV type aircraft carriers (Nimitz, Forrestal, Kennedy, etc.) overhangs the pier when berthed bow in on the south side, carriers must enter this berth stern first. Seven to ten tugs are used to turn the aircraft carrier for entry into the berth; forward and backing movements of the carrier, however, are carried out by means of the carrier's four 21-foot diameter screws.

The fouling problem appears to be threefold:

a. Biofouling of condenser tubes by masses of marine organisms that have been broken loose at other parts of the harbor by mechanical action (presumably as the result of storms) and transported to Pier 12 by currents.

b. Fine-grain material previously deposited at the bottom of the berth being picked up and carried into the condenser tubes.

c. Erosion of the submarine walls of the relatively narrow berth by the screws of a carrier when the carrier is entering the berth at an angle to the pier.

The action scheduled by the Naval Station to correct these problems is:

1. To remove periodically the masses of organic material with oyster rakes or mesh baskets (dredges) six feet wide towed along the bottom by a 40-foot boat. The program was started during July 1976.

2. To widen the entrance to both berths at Pier 12. Dredging to start at the 45-foot isobath in the channel west of Pier 12 to the original berth at a point along the original outside submarine walls of the berth. This program as of July 20, 1976 was still in the drawing board stage.

As a result of investigating the various dredging methods, it would appear that agitation dredging using an I-beam attached to a Navy tug, the use of propeller wash where the propeller axis is held vertically, and the Pneuma system all hold promise.

Owing to the fact that solution and resuspension of pollutants take place in the agitation method, it would be advisable to contact both the state and federal Environmental Protection Agencies. Inasmuch as sediments from the pier slip will be deposited in the main shipping channel, the Corps of Engineers should also be involved in the plan.

In order to obtain specific information on the Pneuma system, Pneuma North America, Inc., was contacted for a proposal to lease to the U. S. Navy the Pneuma dredge with the U. S. Navy supplying the ancillary equipment. Also, a proposal was submitted to be responsible for the dredging of Pier 12 and maintaining the depth at 45 to 50 feet below MLLW within six inches.

Two leasing proposals were submitted by Pneuma North America, Inc. A comparison made by Pneuma North America, Inc. is as follows:

	PROPOSAL A	PROPOSAL B
Type Vessel	30 x 80 Deck Barge	1,600 Ton Hopper Barge
Barge Propulsion	2 - 125 HP Harbor Masters	2 - 125 HP Harbor Masters
PNEUMA SYSTEM	Model 600	Model 450
Estimated Production	700 C.Y. Slurry Per Hour	525 C.Y. Slurry Per Hour
% Solids Dredged	40	40
Number of Days Required to remove 6" accretion in Area A or B or C	7	13
Crew Size (Dredge only)	5	5
Attendant Plant Required	Tug Boat Hopper Barge	None
Mobilization Cost	$82,000 plus Navy Labor and Equipment to Assemble	Complete Cost - $207,000.00
Monthly Lease Amount 1st Year	$36,000.00	$43,000.00
Monthly Lease Amount After 1st Year	$20,000.00	$17,700.00
Buy out after First Year	$283,000.00 Excluding Compressors	$235,000.00 Including Compressors
Services of PNEUMA Supervisor Included	Yes 10 weeks	Yes 10 weeks
Cost to Dispose at Craney Island	$.80 C.Y.	$.07 C.Y.

Details of these lease proposals are in the writer's files.

Comparison of dredging cost on buy out after first year, based on dredging 14,000 c.y. per month and working two shifts:

<u>First Year</u>

Dredge Rental	$43,000.00 Month ÷ 14,000 c.y.=	$3.07	c.y.
Labor	17,200.00 Month ÷ 14,000 c.y.=	1.22	c.y.
Fuel Cost	.....................=	0.12	c.y.
Cost of Disposal	.....................=	0.07	c.y.
	Cost	$4.48	Per c.y.

<u>Second Year</u>

Dredge Rental	$19,500.00 Month ÷ 14,000 c.y.=	$1.34	c.y.
Labor	17,200.00 Month ÷ 14,000 c.y.=	1.22	c.y.
Fuel Cost	.....................=	0.12	c.y.
Cost of Disposal	.....................=	0.07	c.y.
	Cost	$2.75	Per c.y.

<u>Third and Consecutive Years</u>

Dredge Rental	............No Cost =	$0.00	c.y.
Labor	$17,200.00 Month ÷ 14,000 c.y.=	1.22	c.y.
Fuel Cost	.....................=	0.12	c.y.
Cost of Disposal	.....................=	0.07	c.y.
	Cost	$1.41	Per c.y.

The costs involved in the proposal submitted by Pneuma North America, Inc., to assume all responsibility for dredging and maintaining the bottom of the slip at Pier 12 are as follows:

1. A one time mobilization charge of:

   Two Hundred Seven Thousand and 00/100 Dollars
   ($207,000.00)

   payable 50% upon award of contract and 50% one month after start of mobilization.

2. For a five year maintenance program an annual payment of:

   Six Hundred Fifty-Four Thousand and 00/100 Dollars
   ($654,000.00)

   payable in twelve equal monthly installments of:
   Fifty-Four Thousand Five Hundred and 00/100 Dollars
   ($54,500.00)

3. For a ten year maintenance program an annual payment of:

   Five Hundred Forty-Five Thousand One Hundred Twenty SEven and 00/100 Dollars
   ($545,127.00)

   payable in twelve monthly installments of:
   Forty-Five Thousand Four Hundred Twenty-Seven and 00/100 Dollars
   ($45,427.00)

4. A payment to the U.S. Army Corps of Engineers for use of the Craney Island Disposal Area. We direct pump from our barge into the disposal area. We understand the present charge for that operation is $.07 c.y.

Details are in the writer's files.

The agitation dredging method is by far the cheaper and should be tried providing the necessary clearances can be obtained. The Pneuma method on the other hand is better environmentally.

Dredging Problem - U. S. Navy Submarine Base, Groton, Conn.

Dredging the channel of the Thames River to a depth of 36 feet to enable the passage of the nuclear submarines class SSN688 to the U.S. Naval Submarine Base at Groton, Conn. involves dredging 2.9 million cubic yards of river bottom.

The river is being dredged in two phases. Phase I has been accomplished and the one and one-half million cubic yards of spoil disposed of in the one-mile square New London spoil disposal site two miles off the coast. Opposition by a group known as the National Resources Defense Council (NRDC) resulted in the Navy discontinuing temporarily the dredging program in Phase II. The Environmental Impact Statement was challenged unsuccessfully by the group in court. The Appellate Court, however, overturned the lower court decision in a two to one opinion. The Appellate Court required that additional data be obtained in addition to instituting a large scale monitoring program of the New London dump site where the spoil from Phase I was dumped. The monitoring program consists of: chemical analysis of sediment, biologic examination of dump site, physical and chemical analysis of water column overlying dump site, and bathymetry of dump site.

Discussions were held at Groton, Conn. with:

Mr. Robert Ham, Supervisory Engineer, Public Works, U.S. Navy Submarine Base

Dr. E. N. Jones, Ocean Technology Division, U.S. Navy Underwater System Center

and with LT R. Norris, Project Manager at the Philadelphia Naval Shipyard. The purpose of the discussions were to familiarize the writer with the background of the problem.

These discussions reinforced by the "Final Impact Statement" and the "Supplement to the Final Impact Statement" gives a detailed insight into the background.

Practically all parties agree that deepening the Thames River is a necessity. However, the U.S. Navy backed up by the Environmental Protection

Agency favors the New London dump site. Whereas the Fish and Wildlife Service, and many other parties, favor dumping in the "East Hole" a much greater distance away and involves greater costs. Further, another Environmental Impact Statement may be required at a time when time is of the essence. Both sites are located in Long Island Sound.

One of the areas of disagreement is that the opponents claim that the spoil dumped at the New London dump site will not be contained within the delineated dump site area and that blanketing of benthic organisms outside of that area will take place. The difference in the volumes of the spoil computed from bathymetric measurements made at two different times, both after cessation of dumping, indicated that the volume of spoil decreased five percent suggesting dispersion. On the other hand, consolidation of spoil may be taking place inasmuch as it is only lightly compacted after its fall through the water column at the dump site.

The writer sent to LT Norris background information concerning obtaining undisturbed samples of dredge spoil for consolidation tests: Shelby tube sampling was recommended in lieu of gravity piston core sampling inasmuch as obtaining the sample by the latter method would preconsolidate the sample. Results from the consolidation test would be more conservative than the actual case.

Documents filed in opposition to the "Supplement to the Final Draft of the Environmental Impact Statement" contain the commonly-used term "long term effects" even though, according to Dr. Jones, there are no short-term effects evident, and the abundant use of the word "could" instead of "will". The experts presented no scientific evidence, no scientific literature and no case histories from other areas to support their contentions. The statement to the effect that the clean-up of Long Island Sound was expensive and now the Navy wishes to degrade the Sound is made. It is not clear what is meant by "cleaning up the Sound" but Dr. Jones thinks it might refer to the construction of municipal treatment plants by New York City to replace raw sewage dumping in the Sound.

Another comment made by the environmentalists opposed to using the New London dump site is that long-term effects of pollutants, especially heavy metals, entering the food web would be distributed throughout the web and would affect man ultimately. The opponents, however, did not specify any mechanism nor cite any case histories whereby heavy metals could move from an insoluble state in the sediments through the cell walls of living organisms and become concentrated there. It is agreed that if the heavy metals were in solution this could take place.

A copy of the test results from a study made by the writer for the State of Maryland was left with LT Norris. The results of this study showed that heavy metal compounds in the Chesapeake Bay sediments when heated with hydrochloric acid were dissolved. When heated with Acetic Acid the heavy metal compounds did not dissolve. Both acids have a lower pH than the waters overlying the New London dump site and probably lower than any acids generated by in situ anaerobic conditions.

Some mention was made of the possibility of using in the future a sedimentation basin in the bottom of the Thames River to trap the sediment before it could reach the dredged channel or pier slip. Examination of the salinities of the top and bottom waters at Stations A, B, C, and D[3] indicate that a well developed tidal wedge exists at least in the lower part of the Thames River. Nothing is known about the salinity of the upper part of the Thames River.

Flocculation of suspended sediments takes place where the inflowing fresh water with a load of suspended sediments comes in contact with saltier water.[4] The best location for any sedimentation basin would be north of the dredged channel and south of the toe of the tidal wedge. At such a location, the flocculated suspended sediments would be trapped in the basin before moving into the pier slips or the dredged channel.

Inasmuch as the position of the toe of the tidal wedge is a function of a number of variables, a series of salinity determinations, spatially distributed, should be made through the year, if not for a longer period of time, to better define the above mentioned limit.

SUMMARY AND CONCLUSIONS

The six methods of dredging maintenance of pier slips investigated warrant closer examination by the U. S. Navy. Field application with careful cost accounting is the best way of evaluating the worth of each. The underlying question is how deeply does the U. S. Navy wish to engage in the dredging business even at a cost saving?

Chemical blankets laid down in pier slips to form a non-erodible basement may be a useful adjunct to some of the dredging systems especially agitation dredging where a vertical flow of water could be directed downward to agitate the sediments.

The problem of the clogging of the condensers of aircraft carriers berthed on the south side of Pier 12 has yet to be satisfactorily solved, although the measures discussed in July 1976 may provide the solution. Agitation dredging is the least expensive solution; whereas Pneuma dredging is the most acceptable solution environmentally.

[3] U.S. Dept. of Commerce, 1975, An Environmental Survey of Effects of Dredging and Spoil Disposal, New London, Conn., Second quarterly report. Informal report No. 49. 7 Feb 1975.

[4] Hoffman, John F., 1976, Decrease in Harbor Maintenance Dredging Through the Use of Pile Dikes and Related Structures together with An Analysis of Estuarine Sedimentation Problems USNA-EPRD-29. Prepared for Naval Material Command, Washington, D.C.

The problem encountered in the offshore disposal of dredge spoil from the Thames River at New London, Groton, Conn., seems to hinge on the long-term effects of heavy metals spoiled to the environment. This has not been supported by case histories or even laboratory studies by the opponents. The question that has to be resolved is by what mechanism can heavy metal compounds in an insoluble form within the sediments be dissolved to enter the agueous environment and thence the food web?

ADDENDUM

Subsequent to the completion of this report the United States District Court for the District of Connecticut issued an Order of Dismissal authorizing the U. S. Corps of Engineers to reissue a permit to the U.S. Department of the Navy to dispose of the dredge material from its Thames River Project into the New London dump site. Details of the problem are contained on pp. 18-20 of the subject report. This Order was filed by the Clerk U. S. District Court, Hartford, Conn. on 4 January 1977. The exact content of the Order of Dismissal is listed below:

ORDER OF DISMISSAL

Upon application of all parties to this proceeding it is ordered, adjudged and decreed:

I

That this cause be, and is hereby dismissed with prejudice as to its refiling, each party to bear their own costs, and the temporary injunction heretofore issued is hereby dissolved; except that jurisdiction is retained for the sole purpose of adjudication of Plaintiffs' claim for reasonable attorneys fees. This order shall constitute a final judgment for all purposes, except as to the claim for attorneys fees.

The Defendant, United States Army Corps of Engineers (Corps), is authorized to reissue a permit to the United States Department of the Navy (Navy) allowing the Navy to dispose of dredged material from its Thames River Project into the New London dump site. When the permit is so reissued, it shall include the following conditions:

(A) The Navy will conduct its Phase II dredging operations in a generally North/South Direction, subject to the right of the Navy for national defense reasons to request the Corps for such modifications in the dredging as may be necessary to expeditiously complete the project.

(B) The Navy will, upon commencement of Phase II dredging, continue to monitor the effects of disposal of such dredged material in accordance with the criteria set forth in this permit, as they may be

modified, which monitoring will include radiological, chemical or equivalent tracing of sediment dispersal and comprehensive biological uptake studies at the dumpsite, unless the Corps, after receipt of recommendations from the Inter-Agency Scientific Advisory Subcommittee on Ocean Dredging and Spoiling, (ISASODS) (or if a prompt recommendation from ISASODS is not forthcoming, after consultation with ISASODS), determines that such tracing is inappropriate under the circumstances.

(C) The Navy will make available for such monitoring adequate funds to meet the requirements of this permit, provided however, that the funds so to be provided shall not exceed $500,000 over and above the funds heretofore expended.

The deepening of the channel in the Thames River was completed in the Summer of 1978.

APPENDIX A

Outline of a Lecture on

Dredging Fundamentals

1. Purpose of dredging is to:

   a. move submarine or subaerial sediments.
   b. maintain shipping channels.
   c. mining ores.
   d. mining sand and gravel.
   e. aquaculture - clams, oysters, etc.

2. Types of dredges

   a. bucket and scow

      1. clam shell bucket
      2. dipper - steam shovel type

   b. hydraulic: pipeline - cutterhead - pipeline can extend up to a mile in length.

   c. hopper - ship built around box, box filled by a "vacuum cleaner"

   d. ladder - bucket - continuous chain of buckets

   e. exotic methods (not discussed herein)
   Method (b) - continuous dredging action
   Methods (a),(c) - discontinuous dredging action

3. Disposal of Spoil

   a. offshore dumping - governed by Corps of Engineers (attached are excerpts from the pertinent regulations).

   b. diked disposal areas; i.e. Craney Island, Norfolk, Va. harbor; Mobile Bay, Ala. (see attached article).

   c. deep portions of water bodies; i.e., Long Island Sound New London Submarine Base spoil from Thames River; Chesapeake Bay - Kent Island deep, Poole's Island deep. This disposal method is sensitive because of ecology, breeding grounds, etc.

   d. onshore disposal

      1. fill "dead" swamps and wet lands.
      2. fill mined-out quarries, strip mines, etc.
      3. build beaches where large amounts of sand are in the spoil; i.e., along the coast of New Jersey and the Delmarva Peninsula. Fines wash back to sea.

4. Cost per yard - approximate; depends on type of material to be dredged, location of activity and where spoil is to be disposed.

a. hydraulic dredge - Norfolk, Va., to U. S. Navy $2.00/cubic yard (1975)

b. bucket and scow - Baltimore, Md. $1.07/cubic yard for first mile; $.055/cubic yard each mile thereafter up to 18 miles (1969).

c. hopper dredge $.225/cubic yard plus $.036 per cubic yard per mile.

5. Pollution of Receiving Waters

a. turbidity - interferes with photosynthesis and food web.

b. concentration of sludges, chlorinated hydrocarbons, polychlorinated biphenyls (PeB) and heavy metals to centrally located places. If they dissolve, the toxicants would disturb the ecology.

c. biodegradation utilizes oxygen and will deplete the concentration of oxygen dissolved in the water - possibly to a serious degree.

d. blankets bottom organisms such as oysters, clams, fish eggs, fish fry, etc. interferes with proliferation.

Publications Attached

1. Excerpts from EPA Rules and Regulations regarding Transportation for Dumping and Dumping of Material into Ocean Waters.

2. Houston, John, 1967 - Dredging Fundamentals. Journal of the Waterways and Harbors Division Amer. Soc. of Civil Engineers. August 1967.

3. Cable, Carl C., 1969 - Optimum Dredging and Disposal Practices in Estuaries. Journal of the Hydraulics Division Amer. Soc. of Civil Engineers. January 1969.

4. Horn, W. L., Lt.Col., 1969, Craney Island Disposal Area 1954-1969. The Military Engineer No. 403.

5. Kolessar, M. A., Some Engineering Aspects of Disposal of Sediments Dredged from Baltimore Harbor, Paper No. 66 Symposium Sedimentation in Estuaries, Harbors , and Coastal Areas.

6. Engineering News-Record, 1970, "Nixon Proposes Halting Dredge Spoil Dumping" April 23, 1970, p. 115.

TRAVEL ASSOCIATED WITH RESEARCH PROJECT

1. U. S. Naval Base, Norfolk, VA. - July 19-21, 1976

   Purpose: to obtain first-hand information concerning the siltation problem at Pier 12.

2. U. S. Naval Submarine Base, Groton, Conn - August 9-13, 1976

   Purpose: to visit the naval facilities at Groton and New London, Conn., to obtain on-site information concerning the dredging problem at the U. S. Naval Submarine Base.

3. U. S. Naval Shipyard, Philadelphia, PA. - August 25-26, 1976

   Purpose: to discuss the problem of the disposal of dredge spoil offshore of New London, Conn. with the project manager of the study, LT. R. Norris.

4. Virginia Beach Erosion Commission, Virginia Beach, VA. - August 30-September 1, 1976

   Purpose: to obtain first-hand information concerning the sink/crater method of sand by-passing designed by the COE Waterways Experiment Station and used by the Erosion Commission to keep Rudee Inlet open.

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